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ABSTRACT

The purpose of this study was to investigate whether differences in the level of visual complexity in motion visuals have an effect on cognitive learning of students in different grade levels. The instructional content was a 14-minute video lesson concerning the motion of objects in the universe. A 3 (levels of visual complexity) x 2 (grade levels) factorial, pretest-posttest design was used. Three 4th- and three 8th-grade classrooms were randomly assigned to one of the three video treatment groups. Pretest and posttest consisted of 28 multiple-choice questions and were designed to test subjects' comprehension of the instructional content. The results indicated that providing different levels of visual complexity in motion visuals had no significant impact on children's comprehension of the intended learning. Also, no interaction between amount of visual complexity in motion visuals and grade level was found. (Contains 40 references.) (Author)

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The Effects of Visual Complexity in Motion Visuals on Children's Learning

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Abstract

The purpose of this study was to investigate whether differences in the level of visual complexity in motion visuals have an effect on cognitive learning of students in different grade levels. The instructional content was a 14-minute video lesson concerning the motion of objects in the universe. A 3 (levels of visual complexity) × 2 (grade levels) factorial, pretest-posttest design was used. Three 4th- and three 8th-grade classrooms were randomly assigned to one of the three video treatment groups. All subjects received the pretest, treatment, and posttest. Pretest and posttest consisted of 28 multiple-choice questions and were designed to test subject's comprehension of the instructional content. The results indicated that providing different levels of visual complexity in motion visuals had no significant impact on children's comprehension of the intended learning. Also, no interaction between amount of visual complexity in motion visuals and grade level was found.

Introduction

With the continually increasing impact of visual messages in our society, visual instruction has become one of the major methods of communicating information in school settings. A variety of visual materials, such as drawings, photographs, film, television, and computer software, is commonly used to complement regular classroom instruction at all levels of education (Dwyer, 1978, 1982-83). Prior research has demonstrated that pictures are a versatile instructional tool. It can help children learn many different tasks, such as learning from oral prose (Levin & Lesgold, 1978), learning of nonfictional passages taken from newspaper (Levin & Berry, 1980), learning of written text (Levie & Lentz, 1982), and word recognition (Willows, 1978). However, studies of visual instruction also show that the inclusion of a picture in instruction does not automatically improve student achievement (Dwyer, 1978; Levie & Lentz, 1982; Peeck, 1987). Different visuals containing different amount of visual complexity may affect learning differently.

Over the years, two opposite approaches to designing instructional visual materials have arisen from the concept of visual complexity. They are realism theory (Carpenter, 1953; Dale, 1946; Morris, 1946) and relevant cue hypotheses (Miller, 1957; Travers, 1964; Travers & Alvarado, 1970). The basic assumption of realism theory is that learning will be more complete as the amount of visual detail in the instructional materials increases. However, relevant cue hypotheses contend that complex visuals may be interesting to view, but due to the limited capacity of human information processing, this type of visuals is more difficult for the brain to process.

Visual complexity can vary among a great number of different attributes. However, the amount of interior detail in figures and presence of background information are two attributes which have been implicated by researchers as important factors influencing learner's processing of visual information (Dwyer, 1978; Fleming, 1987; Franken, 1977; Nelson, Metzler, & Reed, 1974; Travers, 1969).

In a visual display, critical figures (objects or people) may show extreme variations in amount of interior detail. The range is from full color photographic representations to black-and-white outline drawings that portray only the few edges the artist considers to be of crucial significance in identifying the characters. In some studies, researchers have directly manipulated the amount of figure detail in pictures to determine whether extra interior detail facilitates different levels of learning in the cognitive domain. For example, since 1967 Dwyer (1978, 1982-83) and his associates have conducted more than 100 studies in this area. The results of these studies generally concluded that employing highly detailed, complex illustrations in visual lessons is unnecessary, and it may even impair the intended learning.

In addition to Dwyer's studies, a number of researchers have focused on the roles that varying levels of figure detail play in picture memory (Cody & Madigan, 1982; Evertson & Wicker, 1974; Jesky & Berry, 1991; Nelson, Metzler, & Reed, 1974; Ritchey, 1982; Travers, 1969). Unfortunately, contradictory results are found among these studies. For example, Evertson and Wicker reported that the retention of visual stimuli was positively related to the amount of detail in stimuli, whereas Ritchey found that outlines were recalled significantly better than detailed drawings. Therefore, further research is still needed to determine the influence of the addition of figure detail on cognitive learning.

The influence of background information on cognitive learning is another question examined in the research on visual complexity. Many researchers have indicated that perception of a visual figure is determined not only by its characteristics but also by its surrounding context (e.g., Antes & Metzger, 1980; Fleming, 1987). In general, background information refers to the excess surrounding information in which the critical figure is embedded (Borg & Schuller, 1979; Fleming & Levie, 1978; Sparks, 1973). According to this definition, pictures may vary in the extent to which the critical figure in the picture is presented in context or in isolation. A number of empirical investigations have focused on the presence or absence of background information in a visual. One of the earliest reported studies was conducted by Spaulding (1956). He found that visual information unnecessary to critical figures should be eliminated because it may motivate an interpretation that is not compatible with the purpose of the illustration. However, in contrast to Spaulding's findings, Antes and Metzger (1980) reported that the context (background) of objects helped learners construct a general characterization of the pictures which provided learner expectancies to perform their discrimination task. Therefore, the research results concerning the influence of background information on cognitive learning thus far are inconclusive and usually contradict one another.

While the research indicates that visuals containing varying levels of complexity have different effects upon learning, many researchers find that these effects interact with learner age. A number of empirical studies have been conducted which attempt to establish the relationship between the complexity of a picture and a child's ability to process it (e.g., Collins, 1970; Evertson & Wicker, 1974; Hagen, 1972; Hale & Taweel, 1974; Moore & Sasse, 1971; Pezdek & Chen, 1982; Pezdek, 1987). Although the research results appear inconsistent to some extent, in general, researchers agree that there are age differences in how the children allocate their attention to a visual task. Young children tend to center perceptually on selected aspects of a picture, while older students are better able to view the picture in a more global manner. Unfortunately, however, at present

there is still very little guidance for educators in selecting visuals that are appropriate for use with specific groups of learners.

In reviewing the studies concerning the effect of visual complexity on learning, it is evident that they frequently have used static visual stimuli as the material to be learned. Only a few studies have attempted to investigate the relative effectiveness of motion visuals that employ different levels of visual complexity to complement verbal instruction (Acker & Klein, 1986; Chou, 1991; Dwyer, 1970; Hozaki, 1988). In view of the increasing use of motion visuals in school settings today, there is no doubt that more research work needs to be conducted regarding this area.

The purpose of this study was to examine whether, or to what extent, differences in the level of visual complexity in motion visuals have an effect on cognitive learning of students in different grade levels. Specifically, the amount of figure detail and background information were two attributes of visual complexity examined in this study.

Methods

Subjects

Subjects for the study consisted of three 4th-grade classes (N=78) and three 8th-grade classes (N=72) from two public schools in north central Florida. They were randomly chosen by the two school principals and the school curriculum coordinators. All of the classes selected were average classes and were similar to one another.

Instructional Content

The instructional content selected for this study was a 14-minute video lesson concerning the motion of objects in the universe. The lesson was divided into three units: (a) motion and force, (b) gravity, and (c) the law of inertia. In each unit, a related question was first posed, and then the basic concept as well as some real-life examples of this concept were explained and demonstrated. During the development of the lesson content, it was reviewed periodically by practicing teachers of 4th and 8th grades so that both grade students could easily understand the instructional material.

Instructional Treatments

The treatments for this study were produced in two phases. In phase one, three versions of black-and-white computer animation were created using the ADDmotion animation program that runs on a Macintosh environment. After the three versions of computer animation had been produced, the next phase was to convert them to be three VHS videotapes by recording the image from a computer monitor with a professional studio camera.

The videotapes represented three different levels of visual complexity in motion visuals for this study: outline drawings (OD), outline drawings with added figure detail (ODF), and outline drawings with added figure detail and background information (ODFB). Although the three versions of the video programs had different levels of visual complexity, they all employed the identical verbal narration to complement the visual information.

In the OD version, the computer animation contained only the outline shapes of critical objects necessary to convey the intentional meaning of the picture. Peripheral information, such as figure detail and background, was not included (see Figure 1).

In the ODF version of computer animation, interior detail in figures was added to each frame of the OD version. If the critical information of a frame was a girl pushing a toy car, for example, the

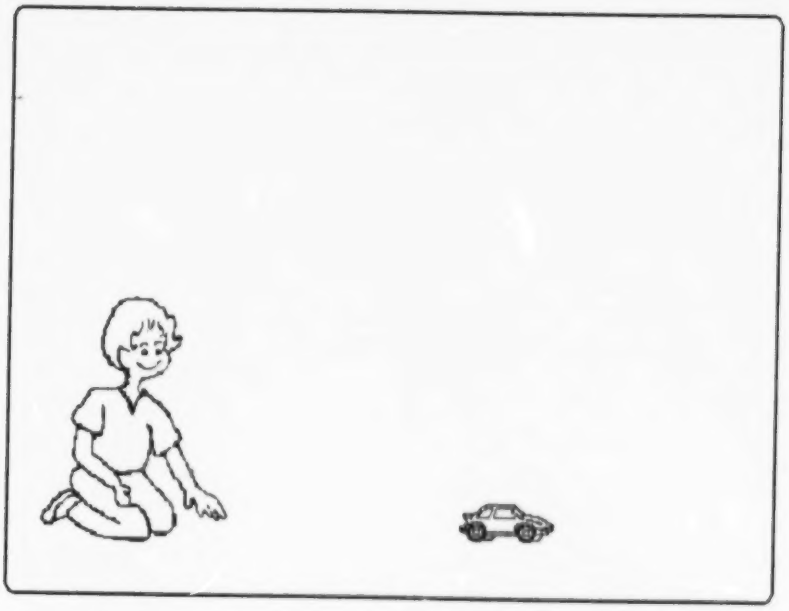

Figure 1: A Sample Frame in Outline Drawings (OD)

added interior detail would include the designs on the girl's clothing as well as shade and design patterns in the toy car (see Figure 2).

The ODFB version was presented with the same visual information as the ODF version except that appropriate background information was provided in each frame. For example, the visual of a girl pulling a toy car in the ODF version would be embedded in a living room in the ODFB version (see Figure 3).

In order to eliminate variables which may confound the research results, all pictures were developed as black-and-white representations. In this way, the possibility of color effect could be avoided.

Instrumentation

The pretest measure (K-R 20 = .87) dealt with the specific content covered in the selected video lesson. It consisted of 28 multiple-choice questions which tested students' comprehension of content which would be presented in the video lesson. The posttest was identical in style to the pretest and consisted of the same 28 items but arranged in a different order. The posttest was administered to the subjects two weeks after the pretest was given.

These measures required that the student had a thorough understanding of the concept of motion, gravity, and the law of inertia. They were designed to determine whether the students comprehended what was communicated and could use the information being received to explain some other phenomena.

Procedure

Three 4th- and three 8th-grade classrooms were randomly assigned to one of the three video treatment groups–OD, ODF, and ODFB group. After being assigned the treatment groups, the

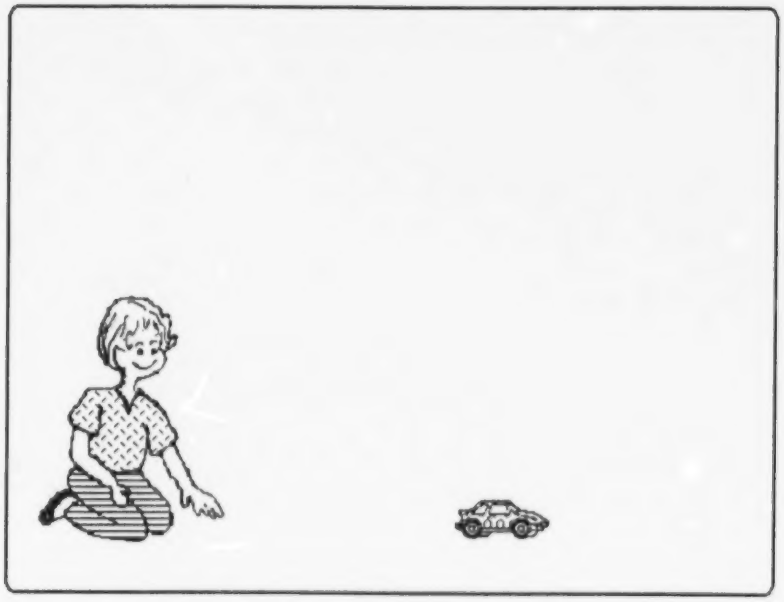

Figure 2: A Sample Frame in Outline Drawings with Added Figure Detail (ODF)

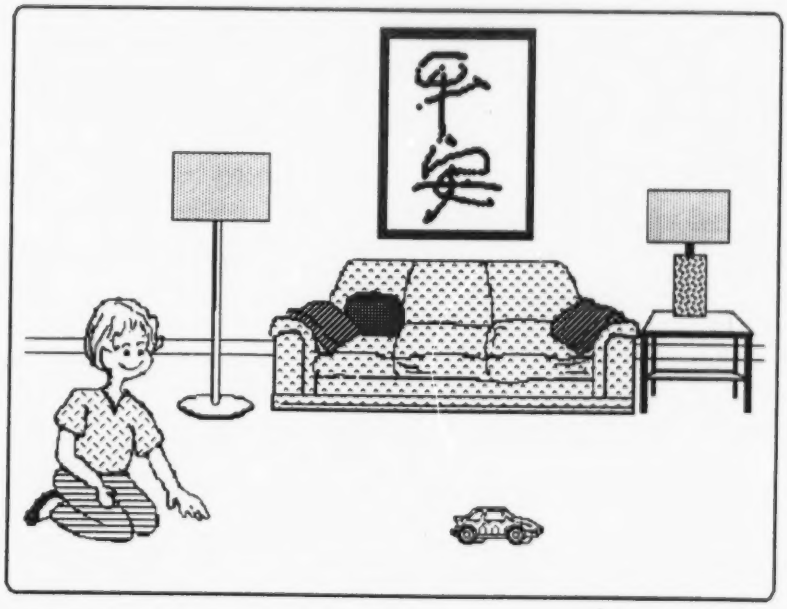

Figure 3: A Sample Frame in Outline Drawings with Added Figure Detail and Background Information (ODFB)

subjects received the pretest to determine their prior knowledge level in the instructional content. However, since the possibility existed that the pretest might activate students' attention toward some specific areas of the video program when they would watch it later, the pretest was administered two weeks before the experimental treatments were delivered.

During the two-week period between the pretest and the experimental treatment, the teachers were asked not to teach the content areas concerning motion and force, gravity, and the law of inertia. They were also requested not to answer students questions relating to these areas.

After two weeks, subjects received their respective experimental treatments. The video treatment was played on a 20-inch monitor. Upon the completion of playing the experimental treatment, subjects received the posttest.

Results

The design of the experiment was a 3 (levels of visual complexity) × 2 (grade levels) factorial, pretest-posttest design. In order to determine whether there were existing group differences in achievement levels of subjects in different treatments, a pretest-posttest correlation and an ANOVA procedure were utilized. Pearson correlation coefficients indicated that pretest was highly correlated to posttest ($r=.75$) and an analysis of variance also showed a significant difference ($F=5.94$, $p<.005$) for pretest scores among the three treatment groups. Therefore, an analysis of covariance procedure (ANCOVA) was used for analyzing main effects and their interactions in this study, while the pretest scores served as a covariate to partial out their effect.

The pretest means, posttest means, standard deviations, and adjusted means for the three treatment groups by grade levels are presented in Table 1. Although the trend of the adjusted mean scores for the three treatment groups in 4th and 8th grade was different, the scores differed very little from group to group, a fact which was reflected in the small F ratios of the analysis of covariance procedure.

Table 1
Pretest Mean, Posttest Mean, Adjusted Mean by Treatment Condition

	4th Grade			8th Grade			Overall
	Pre M (SD)	Post M (SD)	Adj M	Pre M (SD)	Post M (SD)	Adj M	Adj M
OD	12.79 (5.46)	18.04 (7.38)	17.90	21.08 (4.68)	23.04 (5.45)	22.14	19.83
ODF	14.67 (4.10)	18.67 (5.58)	16.81	20.00 (4.38)	22.67 (4.00)	22.47	19.65
ODFB	10.48 (4.77)	13.59 (6.01)	15.57	17.55 (7.04)	19.90 (6.31)	21.30	18.30

Analysis of covariance procedures demonstrate that there were no significant differences for the main effect of treatment ($F=1.64$, $p>.05$), grade ($F=0.08$, $p>.05$), and interaction effect ($F=0.81$, $p>.05$). In addition, the F tests were also computed separately within each grade. All of the respective results are shown in Table 2, 3, and 4.

Table 2
Analysis of Covariance Summary

Source	DF	SS	MS	F
Treatment	2	61.59	30.79	1.64
Grade	1	1.42	1.42	0.08
Treatment × Grade	2	30.33	15.17	0.81

Table 3
Analysis of Covariance for Grade 4 (N=78)

Source	DF	SS	MS	F
Treatment	2	66.54	30.79	1.57

Table 4
Analysis of Covariance for Grade 8 (N=72)

Source	DF	SS	MS	F
Treatment	2	15.54	7.76	0.50

Discussion

The results of this study indicate that providing different levels of visual complexity in motion visuals has no significant impact on children's learning. The use of complex visuals contributes little to facilitate children's comprehension of the intended learning. These findings are in contrast to some earlier research which has previously reported that learning would be more complete as the amount of visual information, figure detail or background, in the instructional materials increased (Antes & Metzger, 1980; Evertson & Wicker, 1974; Snowman & Cunningham, 1976). Although the present study does not find that the most complex version of motion visuals (ODFB) impairs the intended learning, it supports Dwyer's (1978) observation that employing highly detailed, complex illustrations in visual lessons is unnecessary.

There is no interaction between amount of visual complexity in motion visuals and grade level. The differences among the adjusted mean scores for both 4th- and 8th-grader in three treatment groups are small. A number of researchers have theorized and tested the hypothesis that there is a developmental increase in ability to process visual information; specifically, young children have greater difficulty in selectively focusing their attention on the essential learning task than adolescent children (Collins, 1970; Hagen 1972; Hale & Taweel, 1974). However, this hypothesis is not supported in the present study. The adjusted mean scores among three treatments for 4th-graders do show variance (OD=17.90, ODF=16.81, ODFB=15.57), but are not significant. With regard to 8th-graders the variances of three adjusted mean scores are even smaller (OD=22.14, ODF=22.47, ODFB=22.30). Therefore, this study supports the results of Gorman (1973) in finding that the amount of visual complexity in visual instruction has no effect on cognitive learning of students in different grade levels.

Two possible explanations may have accounted for the lack of significant differences in this study. First, in contrast to the prior research which was generally limited to addressing the effects of visuals complexity on recognition and recall, the present study focuses on children's comprehension of visual information. Sigel (1978) has indicated that comprehension must be distinguished from recognition. To comprehend a picture is to extract meaning from the picture, whereas to recognize refers to the identification or labeling of a picture and does not require understanding. In the literature, only a few studies have attempted to include *comprehension* as one of the learning tasks to be examined (e.g. Dwyer, 1971; Hozaki, 1988). However, unlike other instructional tasks such as identification and psychomotor performance investigated in Dwyer's and Hozaki's studies respectively, various levels of visual complexity seldom make a significant impact on comprehension. Thus, this implies that humans may use different cognitive processes to recognize and comprehend a visual display. However, it is still not clear how these two processes are different. Further research has to be done before we can draw a general conclusion on this issue.

A second possible reason accounting for the lack of difference may have been that an insufficient amount of pictorial information was added to the two complex versions of treatments. In reviewing prior research in the field, most studies employed a much wider range of variations in visual complexity. For example, Chou (1991) used realistic video and animated simple computer-generated line graphics as the two levels of visual instruction. In Nelson, Metzler, and Reed's (1974) study the three visual stimulus conditions presented to subjects displayed significant variance: photographs, embellished line drawings, and unembellished line drawings. In contrast, the three treatments used in the present study are all computer-generated line drawings, though figure detail and background information have been added to the two complex versions. Gorman (1973) has suggested that the irrelevant detail did not interfere with the processing of the relevant information presented due to a tolerance level existed for some irrelevant information in a picture. Apparently, this research study is supportive of Gorman's observation. However, it is still not clear what the limits of the tolerance level is. Therefore, if the complexity among three visual treatments in this study could be increased to include a realistic video version, significant achievement differences among treatments may occur.

Several important implications for educational researchers and instructional designers are provided by this study. According to the subjects' progress in their achievement scores, it is clear that the use of visual instruction does improve student's learning. However, the three levels of visual complexity in motion visuals employed in this research study do not have any differential impact on children's comprehension of the intended learning. The more complex visuals are no more effective than the simple one. Therefore, the issue of whether to add extra pictorial information in instructional materials appears to be an economic rather than an instructional consideration. Instructional designers should first consider their budget limitations before making a final decision in selecting and producing appropriate visuals for learners.

The results of this study offers evidence that there is no significant relationship between the treatments and grade levels on learner's comprehension. No treatment condition serves to provide students in different grade levels with a more efficacious visual design strategy for affecting their achievement. Therefore, visual complexity may not be an important factor to be considered when teachers and instructional designers determine how to present motion visuals in order to facilitate the comprehension of learners at different ages. Either a common simple outline drawing or detailed drawing with background format can be used with equal effectiveness with a wide range of students from grade 4 through grade 8.

Another implication provided from this study is that since level of visual complexity is not a physical attribute restricted within a specific medium, the findings of this study may broadly

apply to learning from film, television, computer, interactive video, or multimedia systems. That is, extra pictorial information cannot facilitate comprehension of the information presented in the motion visuals. Even though advanced media such as videodisc or digital video interactive (DVI) can present information that is more realistic, the incorporation of complex and detailed visuals into instructional materials is not necessary.

Recommendations

The results of this empirical study support the need for more extensive investigation concerning the design of visual instruction. The following recommendations are made for additional study in this area:

1. Different cognitive learning tasks could be employed to determine if the factor of visual complexity only influences specific cognitive learning tasks.
2. A wider range of variations in visual information among treatments could be used to determine if the level of complexity in motion visuals affects children's learning.
3. Subjects at a greater age difference could be used to determine whether the effects of visual complexity in motion visuals interact with learner age.
4. Studies could be designed to utilize different subject content areas to determine if the effects of visual complexity are restricted to the specific subject matters.
5. Color and other cueing strategies could be added to the motion visuals to investigate if children's comprehension is affected by them.
6. Besides a multiple-choice test, other types of instruments could be included to examine if different results from the present study would be found.
7. Since a statistical method (ANCOVA) is used in the present study to control subject's existing differences, the same research could be replicated randomly assigning individual subjects to treatments to determine if the classroom effect influences the results of this study.

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